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From this table we get, for the first time, a definite quantitative conception of the average degree of inbreeding existing in any animal. In the complete publication which will shortly follow this note additional details will be given, including probable errors and other statistical constants.

From this analysis of Jersey inbreeding records two results, among others, stand out with particular clearness and significance. These are:

1. That American Jersey cattle, at the present time, may be said in general and on the average to be about one-half as intensely inbred, when account is taken of the eighth ancestral generation, as would be the case if continued brother  $\times$  sister breeding had been followed. The *form* of the inbreeding curve is, however, very different in the two cases, the brother  $\times$  sister curve being concave to the base line throughout, while the actual Jersey curves tend to have their principal curvature convex to the base.

2. That, in general and on the average, Register of Merit animals are *less* intensely inbred than the general population of Jersey cattle.

A detailed report of the work on inbreeding in Jerseys will be published shortly. The above notes are intended to be merely of a preliminary character.

<sup>1</sup> A list of references to these papers will be found in *Amer. Nat.*, **48**, 513 (1914).

## UPPER LIMIT OF THE DEGREE OF TRANSITIVITY OF A SUBSTITUTION GROUP

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In a recent article published in the *Bulletin of the American Mathematical Society* (22, 68, 1915) I proved the following theorem: *A substitution group of degree  $n = kp + r$ ,  $p > k$  and  $r > k$ , which is neither alternating nor symmetric cannot be more than  $r$  times transitive unless  $k = 1$  and  $r = 2$ .* From this theorem and the well known theorem that there is at least one prime number in the interval  $m$  (exclusive) and  $2m - 2$  (inclusive), whenever  $m \leq \frac{1}{2}$ , it results directly that the degree of transitivity of a substitution group of degree  $n$  which does not include the alternating group of this degree must be less than  $3\sqrt{n} - 2$ . In the article noted above the condition  $n > 12$  was added in stating this result but this condition can clearly be omitted.

The general expression  $3\sqrt{n} - 2$  for an upper limit of the degree of transitivity of a substitution group of degree  $n$  which does not include

the alternating group of this degree gives clearly a much smaller value for this upper limit, when  $n$  becomes large, then the expression  $\frac{n}{3} + 1$ , which is found in the standard works of reference, for instance, in Pascal's *Repertorium der höheren Mathematik*, volume 1, (1910), page 211. It may therefore be of interest to note that it is possible to deduce from the italicized theorem noted above a general expression which gives still smaller values for the upper limit in question.

In fact, if  $p$  is a prime number in the interval  $\sqrt{n}$  (exclusive) and  $2\sqrt{n} - 2$  (inclusive) then  $r$  can always be so selected that it does not exceed  $p + n/p$ . Since this expression is an increasing function of  $p$  when  $p > \sqrt{n}$  and has the value  $\frac{5}{2}\sqrt{n}$  when  $p = 2\sqrt{n}$ , it results that the prime number  $p$  can be so chosen that  $r$  is always less than  $\frac{5}{2}\sqrt{n} - 1$ . That is, the degree of transitivity of a substitution group of degree  $n$  which does not include the alternating group of this degree is always less than  $\frac{5}{2}\sqrt{n} - 1$ . For all integral values of  $n > 43$  this theorem gives a smaller upper limit for the degree of transitivity than the formula  $\frac{1}{3}n + 1$ , and for all values of  $n > 4$  it gives a smaller upper limit than  $3\sqrt{n} - 2$ .

## THE EXTENSION OF THE MONTANA PHOSPHATE DEPOSITS NORTHWARD INTO CANADA

By Frank D. Adams and W. J. Dick

COMMISSION OF CONSERVATION OF CANADA

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With the development of agriculture in Western Canada there will arise in the not distant future an insistent and ever increasing demand for fertilizers and manures. Phosphoric acid is one of the most important constituents of such fertilizers. While no deposits of phosphates have hitherto been found in Western Canada, great beds of phosphate of lime have in recent years been discovered in Utah, Idaho, Wyoming, and Montana.

It was for the purpose of ascertaining whether these phosphate-bearing rocks extend northward into Canada that the present investigation was undertaken by the Commission of Conservation of Canada.

The phosphate beds from Utah to Montana occur at a certain definite horizon, usually known as the Phosphoria Formation, which is found near the summit of the Pennsylvanian subdivision of the Carboniferous system. This Pennsylvanian is usually composed of four formations, the phosphate lying at the base of the highest of these members and being usually associated with bands of chert.